Visualizing Android Feature Maliciousness through time

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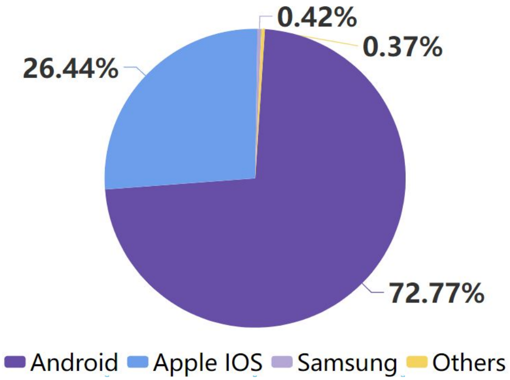
Android

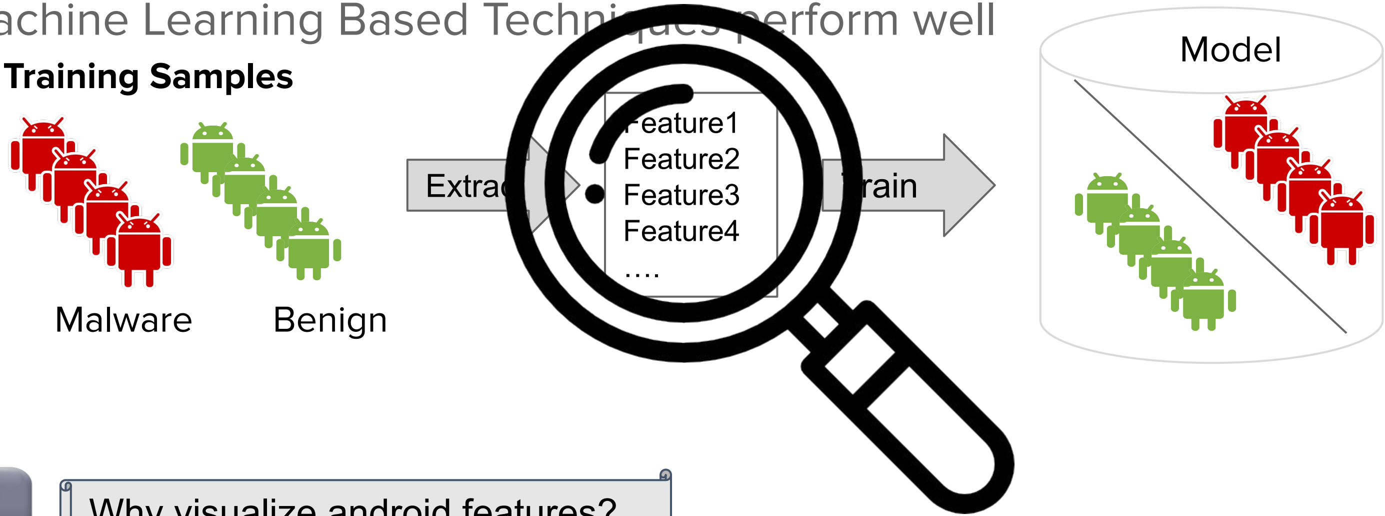
- Most widely used Mobile OS



- 12,000 new Android malware instances every day. unb

Android Malware Detection

- Machine Learning Based Techniques perform well



Training Samples

Malware

Benign

Extrac

Feature1
Feature2
Feature3
Feature4
....

rain

Model

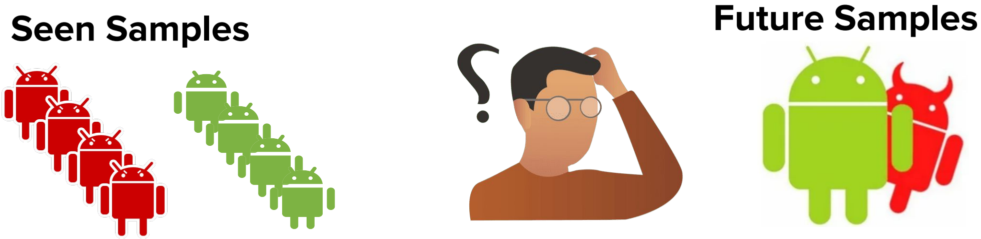
Why visualize android features?

- Aid in Feature Selection
  - Eg. Selecting features more common in malware applications can help boost robustness [1]

[1] “On Benign Features in Malware Detection” by Michael Cao et al, ASE, 2020

Sample Selection: Which samples to train on?

- We want to identify future malware



- We can just train on all existing benign and malware samples

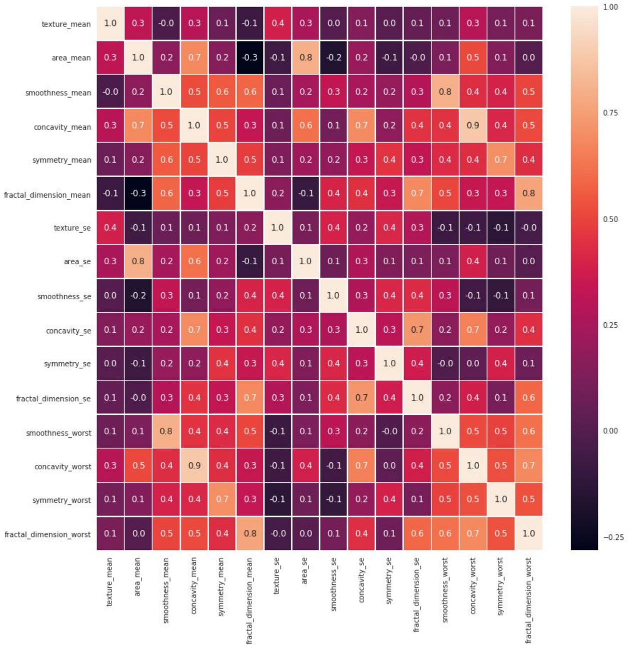
Why visualize android features through time?

- Identify features that can help detect future malware [2]

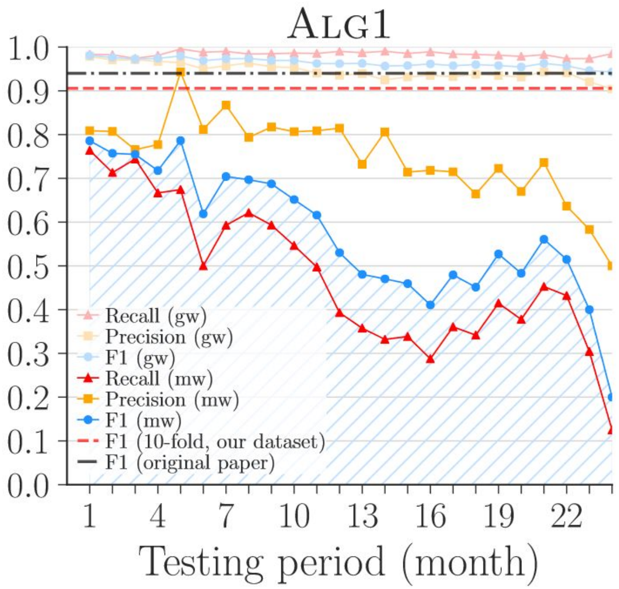
[2] “TESSERACT: Eliminating Experimental Bias in Malware Classification across Space and Time. by Pendlebury et al, USENIX, 2019

Related Work: Visualizations

1. Correlation Between Features



2. Model Performance through time



Data:

- Android Applications represented as a set of (DREBIN) features
    - Benign and Malware Android applications
        - Eg. app1: { feature1, feature3, feature5 } label: benign
- Feature selection metrics and their results
    - Features ranked according the feature selection metrics
        - Eg. Mutual info metric: {feature3, feature1, feature2}

Derived Attributes:

$$Maliciousness\ of\ \ Feature\ x = \frac{Malicious\ Apps\ with\ x\ -\ Benign\ Apps\ with\ x}{Total\ Number\ of\ \ Apps\ with\ x}$$

- -1 => x only in malware apps
- 1 => x only in benign apps

$$Normalized\ freq\ of\ \ Feature\ x = \frac{Apps\ with\ Feature\ x}{Total\ Number\ of\ \ Apps}$$

- 1 => All apps contain x
- 0 => No apps contain x

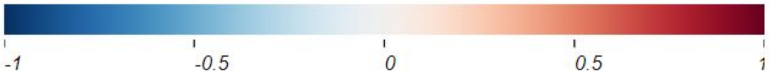
Data Abstraction Summary

Attribute	**Kind**
Feature	Categorical
Feature Set / Feature Family	Categorical
App Development Year	Ordinal
Feature Maliciousness	Quantitative
Feature Normalized Frequency	Quantitative

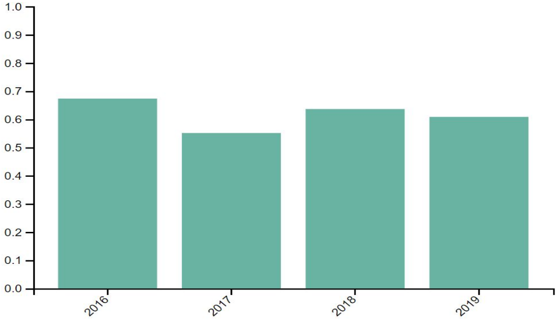
Goal: Identify feature trends in android applications
Target Group: Malware detection tool developers

Visualization Design: Encodings

- Feature Maliciousness over time using heatmap
  - **y-axis:** Feature **x-axis**: Development year
  - Maliciousness encoded by **Blue-Red Diverging Scale**



- Normalized frequency over time using bar charts
  - **y-axis:** Feature **x-axis**: Development year
  - **Bar height**: Normalized frequency of a feature

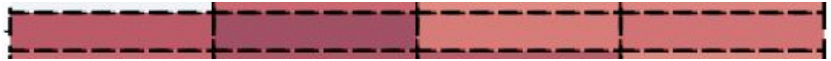


Normalized Frequency per year of selected feature

usedpermissionslist_android.permission.internet

Visualization Design: View Manipulation

- **Requirement 1**: Accommodate for large number of features
  - Design Solution
    - **Filter** features based on feature set
    - **Order** features based on popularity, maliciousness, ...
    - **Alter view** using scrolling
- **Requirement 2**: Show selected features
  - Design solution
    - Show selection using **dashed border lines**



- **Requirement 3**: Display normalized frequency of a feature on demand
  - Design solution
    - Add side view bar chart upon selection

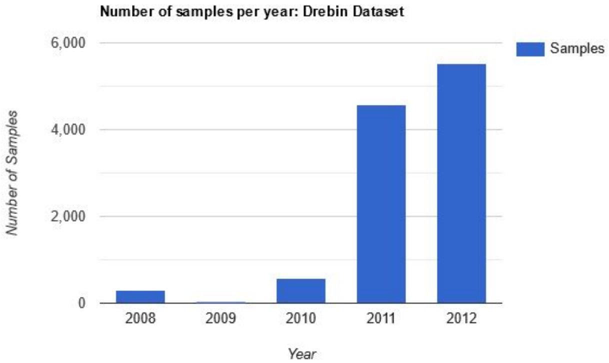
Demo

http://127.0.0.1:5500/index.html

Limitations and Future Work

Limitations:

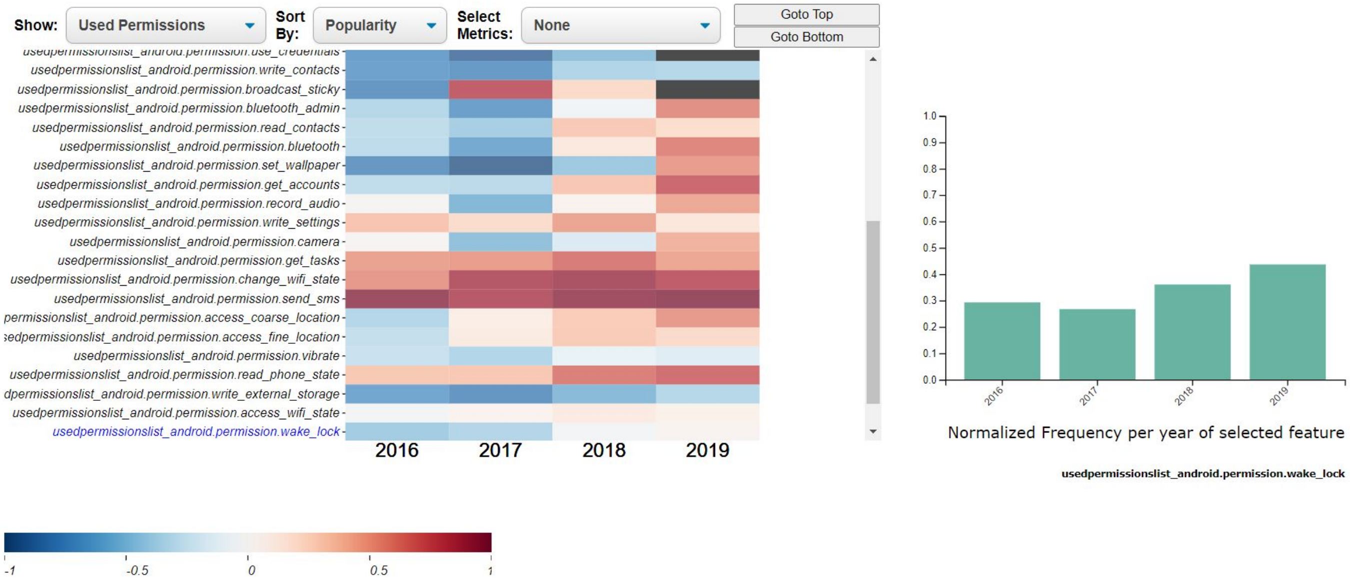
- Sampling bias in dataset
  - Eg. Drebin Dataset:



- Short time duration for the two datasets (VT: 4 years, DREBIN: 5 years)
- Still a large number of features (Scrolling required)

Future work:

- Hand select features and train models directly on the vis interface
- Extend for any domain that requires analysis of features for feature selection



Show: Used Permissions

Sort By: Popularity

Select Metrics: None

Goto Top
Goto Bottom
usedpermissionslist_android.permission.use_credentials
usedpermissionslist_android.permission.write_contacts
usedpermissionslist_android.permission.broadcast_sticky
usedpermissionslist_android.permission.bluetooth_admin
usedpermissionslist_android.permission.read_contacts
usedpermissionslist_android.permission.bluetooth
usedpermissionslist_android.permission.set_wallpaper
usedpermissionslist_android.permission.get_accounts
usedpermissionslist_android.permission.record_audio
usedpermissionslist_android.permission.write_settings
usedpermissionslist_android.permission.camera
usedpermissionslist_android.permission.get_tasks
usedpermissionslist_android.permission.change_wifi_state
usedpermissionslist_android.permission.send_sms
permissionslist_android.permission.access_coarse_location
sedpermissionslist_android.permission.access_fine_location
usedpermissionslist_android.permission.vibrate
usedpermissionslist_android.permission.read_phone_state
dpermissionslist_android.permission.write_external_storage
usedpermissionslist_android.permission.access_wifi_state
usedpermissionslist_android.permission.wake_lock
2016
2017
2018
2019
-1
-0.5
0
0.5
1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2016
2017
2018
2019
Normalized Frequency per year of selected feature
usedpermissionslist_android.permission.wake_lock

Thank you!

Questions?